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Storage management to . . .

Preserve the Energy and Protein of Forages

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To preserve the greatest amount of high quality protein and available energy in forages, it is necessary to understand and manage storage losses. There are six types of storage losses which can occur in harvest systems: 1) respiration; 2) fermentation; 3) seepage; 4) surface spoilage; 5) heat damage and 6) weathering.

Respiration losses are due to continued excess respiration of plant cells due to air within the silage mass. This causes valuable carbohydrates, or sugars, to be converted to carbon dioxide gas, water and heat. Fermentation loss is due to excess conversion of sugars to carbon dioxide and water by yeast and molds contained on the plant material. Seepage loss is caused by the weight of the silage compressing the silage mass. Moisture from the silo carries with it valuable carbohydrates. Seepage also results from collapse of plant cell structures. Surface spoilage occurs when the less compacted silage in the upper silo is exposed to air. Heat damage, particularly in dryer silages, is caused by excessive respiration and oxidation by micro-organisms. Heat damage reduces the availability of protein and energy components. Weathering occurs as surface spoilage in big package hay systems where bales are stored in the open.

These losses can be measured in terms of quantity, or weight loss, and quality, or feeding value. The fact that some silage may experience little dry matter (DM) loss does not necessarily mean there is no great quality loss in feeding value. Figure 1 shows the types and degrees of loss usually associated with various forage systems. Measuring such losses is difficult and the figures shown do not reflect all situations.

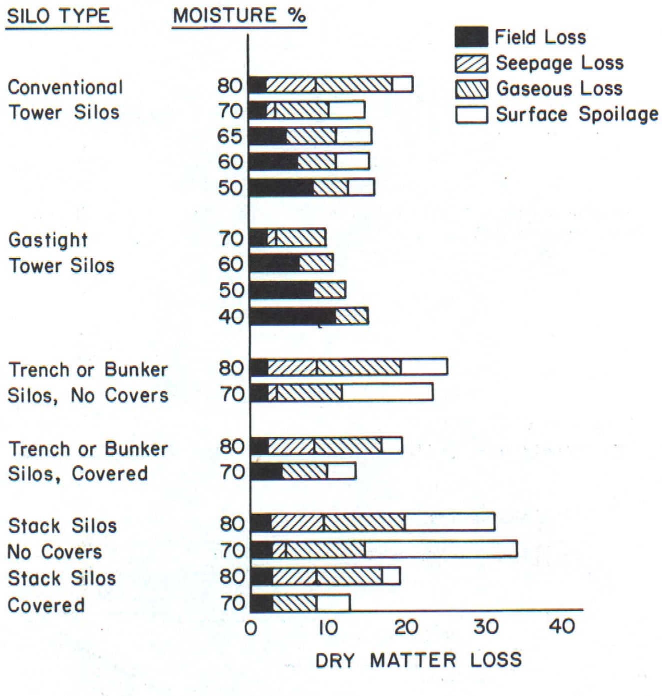
The Harvest System

The degree of storage and harvest loss is primarily affected by DM content of the forage. However, a variety of factors affect the harvest system as shown in Figure 2. All such factors may contribute to make certain types and degrees of harvest and storage losses inherent in a particular system. Wilting to higher DM levels results in higher harvest losses and lower storage losses. This relationship can be seen in Figure 3. Note that field-cured hay has the highest harvest loss and lowest storage loss. At the other extreme, direct cut silage has the lowest harvest loss and highest storage loss. Making silage helps you avoid costly, if not ruinous, weather damage by reducing on-the-field drying time.

Degree of Losses

Field-cured hay will generally suffer a 2 to 6% DM loss in storage in addition to a 15 to 20% DM harvest loss (1) (p. 6). Unfavorable weather conditions can

FIGURE 1. TYPES OF STORAGE LOSS



After: Heath, M.E.; Metcalfe, D.S.; and Barnes, R.E. Forages. 3rd ed. Iowa State University Press, Ames, Iowa. 1973.

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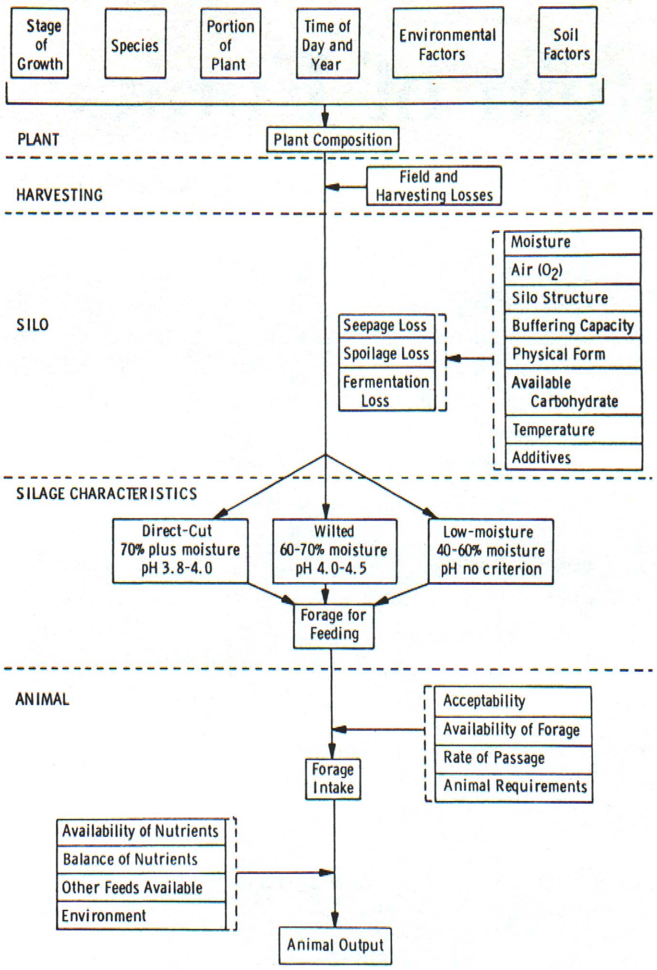
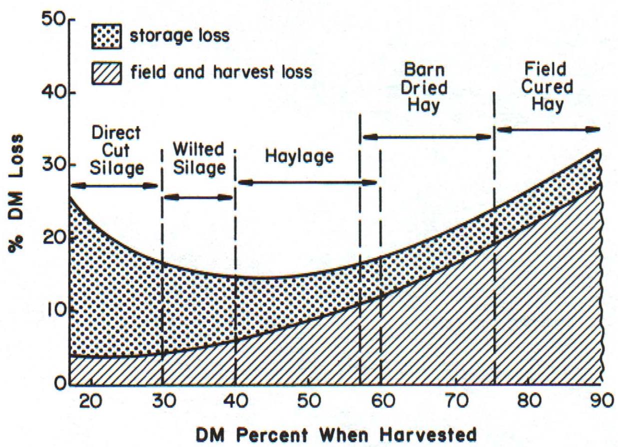
SYSTEMS ANALYSIS DAIRY

FIGURE 2. THE HARVEST SYSTEM



From Heath, M.E., Metcalfe, D.S., and Barnes, R.E. Forages 3rd ed. Iowa State University Press, Ames, Iowa. 1973.

FIGURE 3.
ESTIMATED FIELD AND HARVEST LOSS AND STORAGE LOSS



raise harvest losses to 50%. Big-package hay will incur even greater storage losses. Trials by Purdue University indicated additional weathering loss of 10.1, 10.8 and 19.5% in Hesston 10, Vermeer 605 and Hawk-Bilt 480 packages (see Table 1) (2). Trials by the Auburn University Agricultural Experiment Station demonstrated DM losses of 13.64 and 14.68% for the Stakhand 30 package (3). Big-package hay systems also incur sizable feeding losses. Field feeding can loose 23 to 39% DM. Using a rack can reduce this loss to less than 4%.

Wilting the crop to 40 to 50% DM will reduce field losses, but raise storage losses. Research at the University of Wisconsin shows average DM losses of 9% in concrete silos filled with alfalfa-grass haylage or silage (4). Oxygen-limiting silos (air tight) containing similar material suffered 7% DM losses, indicating that losses can be held nearly the same in concrete tower silos as in oxygen-limiting silos, with proper management. Averages of all materials ensiled (alfalfa-grass, corn-silage, high moisture corn, oatlage and soybean-millet) in 51 silos (29 oxygen-limiting and 22 concrete stave) indicate only a 1% difference in DM storage loss for forages averaging between 40 and 60% DM when ensiled (see Table 2): Storage losses can be held to these levels by proper management practices.

Wilting the crop to 35% DM reduces field losses to 4 or 5%. In conventional silos, DM storage loss can range from 5 to 20%. Using a plastic silo cap can considerably reduce this loss. Oxygen-limiting silos will normally keep losses down to 12% and below (6). DM losses greater than 12% in either type of silo indicate need for improved management.

Low DM forages incur high seepage loss in conventional silos and cause mechanical difficulties in air-tight silos. Bunker silos are more suitable for these low DM ranges. Direct cut silage stored in a bunker is generally equivalent to wilted silage in a conventional silo.

Data on corn silage storage losses is limited. With proper management corn silage at 35% DM may suffer 8% DM loss in conventional concrete towers and 3% in oxygen-limiting silos (1). The Wisconsin studies show a 6% DM average storage loss for 35% DM corn silage in conventionals (4). At 30% DM, these losses could jump to 11% in conventional silos and 6% in oxygen-limiting silos (1).

Forage Quality

The quality, or feeding value, of forages is primarily affected by proper cutting date and weather conditions. In addition, quality can be affected by storage method. Some of the most valuable information on storage losses is being produced at the Institute of

TABLE 1. Weathering losses in grass and legume hay stored outside in various package forms, Southern Indiana-Purdue and Feldun-Purdue Agricultural Centers, 1972 and 1973.*

Type of package	Avg. package wt (15% moisture)	Portion of each package weathered†	Total digest. nutrients‡		TDN loss due to outside storage
			Unweathered core	Weathered outside§	
	lb	%	%	%	% of total
Grass hay — 1972					
Hesston 10 stack	1195	12.6	53.4	35.1	8.83
Vermeer 605 bale	1089	14.6	54.0	39.4	8.20
Hawk-Bilt 480 bale	560	22.2	54.8	39.7	12.59
Small round bale	35	20.6	55.3	33.0	16.87
AVERAGE (big packages)		16.4	54.1	38.1	9.87
Grass hay — 1973					
Hesston 10 stack	1007	9.6	60.0	42.2	6.82
Vermeer 605 bale	1185	7.0	58.9	42.5	4.60
Hawk-Bilt 480 bale	683	16.8	57.9	40.4	11.29
Small round bale	37	20.2	60.0	42.6	13.45
AVERAGE (big packages)		11.1	58.9	41.7	7.57
Alfalfa hay — 1973					
Hesston 10 stack	1377	8.1	57.0	33.9	7.36
Vermeer 605 bale	1097	10.7	56.5	34.2	9.14
Hawk-Bilt 480 bale	728	19.6	56.6	31.9	17.75
AVERAGE (big packages)		12.8	56.7	33.3	11.42
Average — 1972 and 1973					
Hesston 10 stack		10.1			7.67
Vermeer 605 bale		10.8			7.31
Hawk-Bilt 480 bale		19.5			13.87
AVERAGE (overall)		13.47			9.62

*Grass hay stored from June to November 1972, and from June 1972 to February 1973; alfalfa hay stored from August 1973 to February 1974.
†Separation of hay into weathered and unweathered parts was done by hand.
‡TDN estimated on a basis of in vitro (laboratory) dry matter disappearance.
§It is likely that cattle will entirely reject weathered portion even if part of it is digestible.

Forage Production and Conservation in Braunschweig, Germany. Figure 4 indicates DM and energy losses for various moisture ranges. Wilting silage reduces DM loss and energy loss during storage (while still helping you "beat the weather").

Figure 5 shows energy preserved as measured both in Germany and earlier USDA trials (5). Wilted silage has high energy retention in both studies — 80.5% and 83%, respectively. (Dehydrated hay is not currently in common usage in the U.S.) The USDA studies also compared digestible protein values of wilted silage and hay in four harvest trials. Wilted silage preserves more digestible protein in each trial. Wilted silage is also favored with higher carotene values.

When hay is put up in big-packages, there is considerable reduction in DM digestibility. The Auburn trials indicate reductions of 11.4% (Hesston stack), 10.3% (Hesston stack) and 7.4% (Vermeer round

FIGURE 4.
FORAGE LOSSES IN STORAGE
(Honig and Rohr, 1974, Braunschweig, Germany)

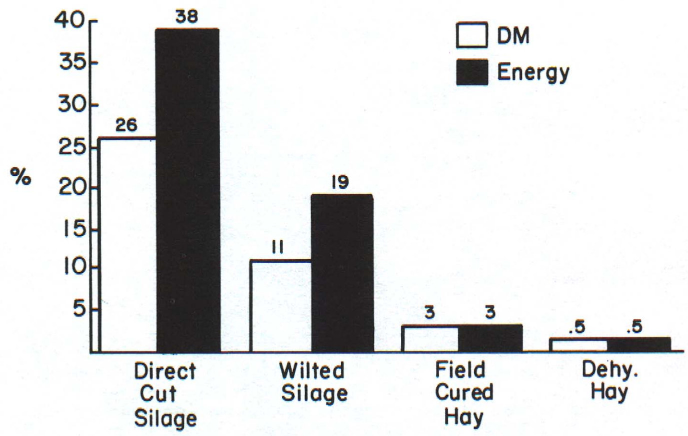


TABLE 2. Summary of dry matter recovered from different types of silage storage units.

	% DM stored	% DM recovered
A. Cement stave silo vs. oxygen-limiting storage units		
22 — concrete stave (all types of material)	42	91
29 — oxygen limiting (all types of material)	54	92
B. Alfalfa-grass haylage or silage		
8 — concrete stave	41	91
15 — oxygen limiting	47	93
C. High moisture ensiled ear corn		
3 — concrete stave	67	87
11 — oxygen limiting	63	91
D. Corn silage (whole plant)		
9 — concrete stave	34	94
0 — oxygen limiting	—	—
E. Oatlage and soybean millet		
2 — oxygen limiting	47	92

bale) in DM digestibility. This corresponds to reduced DM intake and consequent decreased production. (See Extension Bulletin E-842, Big-Package Haymaking Systems: Pros and Cons.)

Heat damage is a frequently unmeasured quality loss, particularly in dryer silages. Excess heat due to poor packing and air pockets can cause caramelization, resulting in up to 40% reduction in digestible protein. Energy losses of similar magnitude can occur. Studies in Michigan and Minnesota show that one-

FIGURE 5.
ENERGY PRESERVED (Forage Harvesting and Storage Methods)

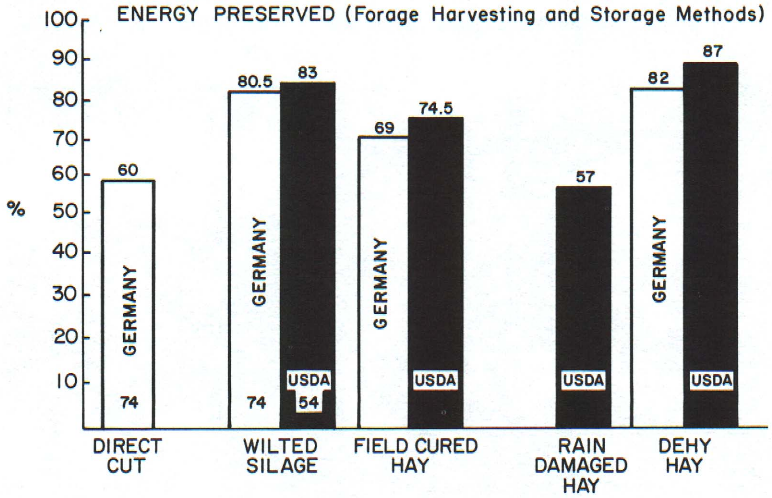


TABLE 3. Effect of heating during storage on the composition and digestibility of haylage.

Composition	Control (%)	Heated (%)
Dry matter	48.5	55.4
Crude protein	19.0	18.7
Crude fiber	22.6	21.7
Acid detergent lignin	8.8	15.9
Acid detergent fiber	34.6	43.7
Nitrogen in acid detergent fiber	8.2	28.3
Digestion coefficients with lambs:		
Dry matter digested, %	61.2	52.2
Crude protein digested, %	70.8	43.0
Calculated N digestion coef., %	64.6	44.1
Digestible Protein content	13.5	8.0

third of the samples taken from farms were heat-damaged and averaged 79% of the assumed protein value, regardless of silo type (6) (Table 3). Available protein is not measured by common crude protein analysis. Dairymen having a feed analysis done should request the acid detergent fiber-nitrogen (ADF-N) test to determine protein digestibility.

Efficiency of Storage Methods

Forage put up as dry hay runs a high risk of being weather damaged, regardless of package type. This is particularly true in wet areas like the North Central and Northeast regions. Making silage virtually eliminates this risk with only a comparatively minimal increase in storage loss. You can keep storage losses to a minimum, but you can't always "beat the weather" unless you reduce on-the-field drying time by making silage.

Cornell University scientists have attempted to measure the relative efficiency of various storage methods compared to barn-dried hay in terms of milk production per acre. Adjustments for varied intakes were made. Highest efficiencies were at 30% to 40% DM content in conventional and oxygen-limiting silos. However, most manufacturers of oxygen-limiting silos do not recommend ensiling these wetter silages due to the weight of the material on bottom unloaders and the mechanical problems associated with freezing (7) (Table 4).

Management Practices

Proper management is a must for reducing storage losses. Big-package hay should be stored at less than 25% moisture and large bales should be stored 12″ to 18″ apart on a well-drained surface. In areas of heavy rainfall, such as much of the Northern and Eastern United States, a covered storage shed should be used to prevent severe losses from weathering and interior molding.

When ensiling forages, air-exclusion is the prime goal. The following procedures are recommended to exclude air from the silage mass.

1) **Provide a tight silo:** The walls and doors of new silos are usually air-tight. However, older silos may have air leaks in the walls or around the doors. These should be reconditioned by a reputable silo repair company and/or caulked and sealed. The drain hole should be plugged if haylage is to be kept in the silo. While semi-sealed silos are helpful for excluding air, they are not air-tight since they must be opened for feeding and air can penetrate the loosely packed forage.

2) **Maintain the proper moisture content:** Alfalfa will retain 70% moisture (30% DM) without seepage at normal silo pressures. To allow for a safe operating range, start filling when the forage has wilted to about 70% moisture. Later loads will be dryer but most of the loads will be 50% moisture or more. Haylage usually contains 40 to 60% moisture. However, if you wait until 50% moisture before filling, much of the forage will be too dry to insure good packing and risk of heat damage will be great.

Corn silage should be stored at 30 to 35% DM to prevent severe seepage in tower silos and can be stored at 27 to 30% DM in bunker silos. Sufficient moisture is required for suitable compaction. Air will move six times easier through haylage containing 50% moisture than through slightly wilted forage. (See Michigan State University Extension Bulletin E-441, "An Easy Moisture Test for Forages and Grains" or use a commercially made moisture tester).

3) **Harvest at proper stage of maturity:** Legumes such as alfalfa and clover should be harvested in the early bloom stage; grasses in the early stage of heading. Such forages pack better in the silo than more mature fibrous material. Also, forages harvested in the early stages of growth are higher in protein and energy value and more palatable. This means higher milk production and daily gains. Corn should be harvested when the kernels are in the early dent to late dent stage of maturity and completed as soon as possible. At this stage, corn plant DM is between 30 and 40%. DM in the kernels will vary from 50 to 65%.

4) **Use the proper cut:** Fine chopping helps to exclude air because packing is tighter. A ¼-inch cut is desirable with 65% moisture silage and absolutely necessary with haylage containing less than 60% moisture. The correct chop is necessary for both conventional and sealed tower silos. Air will penetrate the

TABLE 4. Relative value of hay crop silages compared to barn-dried hay for total milk yield per acre.

Forage: Moisture content & type of storage	Potential DM in field	Avg. field & harvesting losses	Net tons DM stored	Avg. storage loss	Net DM for feeding	Efficiency	Equivalent tons of hay DM	Total value relative to hay
	tons	%	tons		tons	%	tons	%
70% moisture and higher								
— Conventional tower silo	100	2	98	23	75	110	83	104
60 to 70% moisture								
— Conventional tower silo	100	5	95	12	84	108	91	114
— Air-tight silo[1]	100	5	95	6	89	108	96	120
35-60% moisture								
55% moisture								
— Conventional tower silo	100	8	92	12	81	101	82	103
Air-tight silo[1]	100	8	92	4	88	101	89	111
50% moisture								
— Air-tight silo	100	10	90	3	87	101	88	110
40% moisture								
— Air-tight silo	100	13	87	2	85	101	86	108
Barn-dried hay								
(25-35% moisture)	100	15	85	6	80	100	80	100

[1] The highest values for air-tight silos are obtained at these moisture levels which are higher than those usually recommended by some of the manufacturers of air-tight silos. In some cases, bottom unloading and freezing may be a greater problem at higher moisture contents. (This would also seem to be a possibility with corn silage which usually contains about 70% moisture).

mass of haylage in sealed towers when the filling port is left open or when the unloading door is opened for feeding. Chopper blades must be sharp and set correctly. Ledger bars must not be badly worn. Chopping finer than ¼" is not necessary and undesirable if silage is the only roughage source.

5) Distribute evenly in the silo: Even distribution in the silo is necessary to avoid separation of the light from heavier material by the silage blower. Light material tends to land next to he wall. This lends to poor packing and easy air penetration. If the wall happens to leak air, or when the feeding door is opened in bottom-unloading silos, a chimney effect is produced. Also, the pumping action of changing temperatures and gas pressures at various locations in the silo causes air to move into and out of poorly packed silos.

6) Fill the silo rapidly — continuously if possible: Compaction of the forage depends on considerable height of the material to provide the weight necessary to express air from the mass. Therefore, the upper portion will tend to be less dense and hold more air which causes heating. If filling is delayed over several days, the upper layer from each filling will be noticeably different in quality.

7) Apply a top seal: Sufficient moisture is necessary to supply weight for compaction. Forage in the upper one-third of the silo should contain 65 to 70% moisture. Forage should be leveled and tramped to express air.

8) Crown the center: Crown the center and cover with a plastic sheet if feeding is delayed for several weeks. Dig a trough around the silo wall and place the plastic down into the trough and up the silo wall.

When using a bunker silo, 65 to 72% moisture silage is best. Pack continuously with a wheel-type tractor while filling and periodically for 2 or 3 days after filling. Cover with a plastic sheet weighted down by a heavy material.

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